

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

A335.9
R882T

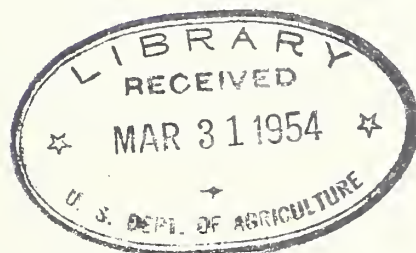
UNITED STATES
DEPARTMENT OF AGRICULTURE
LIBRARY



BOOK NUMBER A335.9
R882T

5.9
827
2

THERMOPLASTIC INSULATED AND SHEATHED TELEPHONE
CABLE FOR RURAL ELECTRIFICATION ADMINISTRATION
TELEPHONE BORROWERS' SYSTEMS



Second Annual Symposium *on*
Technical Progress in
Communication Wires & Cables
December 14, 15 and 16, 1953
Asbury Park, New Jersey



THERMOPLASTIC INSULATED AND SHEATHED TELEPHONE
CABLE FOR RURAL ELECTRIFICATION ADMINISTRATION
TELEPHONE BORROWERS' SYSTEMS

A. L. Richey, Consultant
Telephone Engineering Division
Rural Electrification Administration

J. L. Robb
Telephone Engineering Division
Rural Electrification Administration

In October of 1949, the Rural Electrification Act was amended to permit loans to be made for the purpose of extending telephone service to rural areas.

It has long been the policy of REA to establish standards governing the design and construction of REA-financed systems. Specifications for materials are, of course, included in these standards. Wherever possible existing standards of nationally recognized organizations such as the A.S.T.M., the A.S.A., the E.E.I. and the A.A.R. are used. In undertaking to establish standards in the field of telephone system design and construction, REA found that national standards generally do not exist. It was necessary, therefore, to initiate a rather extensive program of preparation of specifications covering materials used in telephone system construction. This took place early in 1950 and the preparation of a specification covering plastic insulated, plastic sheathed cable was included in the program. At that time, however, there was only one supplier of this type of cable to the telephone industry. Further, the extent to which this type of cable would be employed on REA-financed systems was unknown. As a result of these two factors, the preparation of this specification was postponed. A little over a year ago the actual preparation of this specification was initiated and culminated in a meeting in July of this year attended by nine suppliers who are currently manufacturing this cable or who have under consideration plans to do so in the future. As a result of this meeting and subsequent comments, the specification was issued in its present form to be effective November 1, 1953.

It is interesting to note that during the period prior to the time the specification was issued, REA-financed systems purchased approximately 2,500,000 feet of this type of cable utilizing 180,000,000 feet of conductor.

Specification Requirements

This specification (a copy of which is attached to this paper) establishes the minimum requirements to be met in plastic insulated cables to be acceptable for use in REA-financed telephone systems.

Cable sizes covered range from 6 to 101 pairs in 19, 22, 24 and 26 gauge. Studies made early in the preparation of the specification indicated that cables of 101 pairs and less would satisfy more than 95 percent of the requirements of REA systems. The most used size is 26 pairs (more than 50%) and the next 51 pairs (about 20%). Nos. 22 and 24 are the predominant gauges, with small amounts of 19 and 26 gauge. 26 gauge has been included because there has been a demand for it in paper insulated cable. There is no information available as to possible difficulties that may be met in applying plastic insulation to

a wire as small as 26 gauge, but one plastic cable manufacturer has indicated that he is unable to insulate 26 gauge wire.

The conductor insulation is polyethylene, the wonder thermoplastic that has come into prominence in the last ten years. The sheath may be either polyethylene or plasticized polyvinyl chloride. Of the two, polyethylene has a distinct advantage in its greater ability to exclude moisture.

Conventional cable core construction is used. Manufacturers may elect to strand the layers in the same or in reversed directions, and, in the larger sizes, multiple unit design may be used. In this arrangement, separately stranded units of 25 or 26 pairs are cabled together to form the cable, (3 units in the 76 pair and 4 units in the 101 pair size).

Between the stranded core and the sheath lie the "core-wrap" and the shield. These are a part of the electrical protection, which will be discussed more fully.

So much for a broad general description. Except for dielectric strength and insulation resistance the electrical characteristics of the cables may be called normal -- the conductors are soft copper, and the average mutual capacitance not over .09 m.f. per mile -- this may be considered "normal" for exchange subscriber cable, and generally will be satisfactory for relatively short toll entrance cable circuits such as will be required in rural telephone systems. Naturally, the specified requirements for dielectric strength and insulation resistance are greater than those required of paper insulated cables since polyethylene readily provides better insulation. Insulation between conductors must withstand 1000 volts, rms and insulation between the cable core and the shield must withstand 3500 volts, rms. The insulation resistance must be not less than 1000 megohm-miles. It should be mentioned that dielectric strength and insulation resistance have not been controlling factors in the determination of the wall thickness of polyethylene on the individual conductors. The mutual capacitance requirement generally will control the wall thickness of the insulation.

Limitation of crosstalk is provided by the provision of unlike twists for pairs adjacent in a layer with a different set of pair twists in adjacent layers. Thus, not less than four pair twists will be needed. Better results with respect to capacitance unbalances would be expected with the use of a larger number of pair twists, so that there is a greater physical separation between pairs of like twist, either in a given layer or in different layers. Reversed stranding of adjacent layers helps to keep the unbalances between layers down, but reversed layers are hardly practicable in units used in multiple unit cable.

There should be little difficulty in meeting the capacitance unbalance limits set up in this specification. Data received to date (10/31/53) indicate the 1000 foot reel averages at about 25 mmf or less with the maximum at about 100 mmf. It is hoped that when more experience has been obtained, lower values of unbalance can be specified.

Lightning protection is based on two things -- (a) the belt of insulation of relatively high dielectric strength surrounding the core, and (b) a metallic shield of aluminum or copper immediately outside the belt insulation. For

maximum benefit, the resistance of the shield should be low. To equal lead sheathed cables, the resistance of the shield should be about 0.6 ohm per 1000 feet, for a cable having a diameter of one inch under the sheath. However, the dielectric strength provided with this type of cable is higher than that obtained from lead-paper cables so that for equal lightning protection, the shield resistance can be higher. Another important factor effected by the shield resistance is induced noise. Generally, low shield resistance together with proper grounding practice will provide substantial benefits in reduction of induced noise that would exist without shielding. The shielding for plastic cable is achieved by most manufacturers by spiral wrapping aluminum or copper tapes. Increasing the thickness of the tape to provide lower shielding increases the cost of the cable; therefore, at the present time, some compromise has been made with respect to shielding requirements. It has been agreed that for the present, resistances as much as four times the value for lead sheath will be acceptable. Of course, the REA telephone program has not been in operation long enough to permit the collection of firsthand information on the effects of lightning and other electrical interference. Published papers by Bell System authors indicate the desirability of low shield resistance and high dielectric strength to achieve relative freedom from such troubles. The practice of plastic cable manufacturers (other than Western Electric Company) to use helically applied tapes for the shield brings in contact resistance at the overlap of the tape. If the same amount of material were used in a tape applied longitudinally, the resistance would be considerably less. It is not known whether a cable with the shield so applied would be sufficiently flexible to permit easy installation in the field. Published Bell System papers, however, indicate the use of longitudinally applied uncorrugated 8 mil aluminum tape on Alpeth cables of about 0.6 inch diameter over the core.

With respect to the material to be used in the cable sheath, whether it be polyethylene or plasticized polyvinyl chloride, no attempt has been made to require that specific compounds be used. Physical characteristics and performance requirements are established by this specification but the compounds to be used to accomplish these objectives are left to the discretion of the manufacturer.

There was considerable discussion with manufacturers, prior to issuance of the new specification, regarding the guaranteed pair practice. For many years, one defective pair per 100 pairs or fraction thereof has been allowed in telephone cable. It is known that the manufacturers of cable seldom take full advantage of this defective pair allowance. In most lengths of cable of less than a few hundred pairs, all conductors will be without fault. Based on this experience, and guided to some extent by the fact that one defective pair in a 26 pair cable means a loss of 4% of the pairs, while in a 101 pair cable, only 1%, an argument was made for the manufacturer to guarantee all pairs in cables up to 101 pairs. It was not possible to get the cable manufacturers to agree to this -- although it was agreed that 6 and 11 pair cables shall have no defective pairs. It is hoped that as more experience is obtained, it will be practicable to require 100% good pairs at least in all 19 gauge cable and in the smaller sizes of the other gauges.

Testing Schedules

This specification requires that sufficient testing be performed to insure

that careful quality control is exercised in the manufacture of the cable and that adequate production tests on completed cables are made.

Testing is divided into two groups. Those tests which are made at periodic intervals on a sampling basis to control the general quality of materials and workmanship and those tests which are made on every length of cable to detect faults and to establish the characteristics of that particular length of cable.

Periodic tests are required on conductor material and resistance, on conductor joints, on polyethylene insulation, on sheath material, on sheath thickness and on insulation resistance.

Tests must be made on each length of cable to measure shield resistance, mutual capacitance and capacitance unbalance.

It is recognized that capacitance unbalance measurements are time consuming and it is intended to use the data accumulated as a result of these tests to establish reasonable values for capacitance unbalances as well as to establish a reasonable periodic testing routine for measuring these values.

Utilization of Plastic Cable on Rural Telephone Systems

Plastic cable has several desirable characteristics among these being its light weight and its ability to maintain its insulating properties in the presence of moisture. Thus, as pointed out in previously published papers, with plastic insulated conductors, a hole in the sheath does not necessarily mean a cable out of service. The full utilization of these advantages, however, is contingent on the solution of problems which are presently unresolved.

Long span construction with light weight cables is not feasible in certain areas of the country due to the low-frequency, high-amplitude vibration which occurs with this type of construction. This problem will have to be solved before full utilization of this type cable is realized.

As with any new product, there is a tendency to improvise modifications of existing techniques and accessories to fit the new product. This is true in the case of plastic cable in that splicing procedures which have been used for paper insulated cables were modified for use with plastic cables. This has resulted in a splicing technique which is not entirely satisfactory, and additional work must be done to develop splicing techniques which take advantage of this cable's desirable characteristics. With respect to cable terminals and loading coils, the same thing has occurred and only recently have cable terminals become available which were designed explicitly for use with plastic cable. In the case of loading coils it has been the practice in the past to splice standard load coil cases having paper or textile insulated stubs directly into plastic cables. In some cases this resulted in a point of low insulation which subsequently led to insulation failures at loading points. The development of loading facilities which have insulation equal to that of the cable itself is necessary.

Conclusion

In recent years the use of plastic cable in telephone systems has increased to the point where some small telephone companies use no other type of cable

in their systems. It appears reasonable to assume that the use of this new type cable will continue to increase until a substantial part of all new telephone cables used on rural telephone systems will be plastic cables. The realization of this development depends on the ability of the manufacturers to improve the cable itself, on the development of suitable accessories to be used with this cable, and on the development of construction techniques suited to this cable.

TENTATIVE SPECIFICATION FOR THERMOPLASTIC-INSULATED
THERMOPLASTIC-SHEATHED TELEPHONE CABLE TO BE USED ON TELEPHONE
SYSTEMS OF REA BORROWERS

Rural Electrification Administration
Department of Agriculture
Washington 25, D. C.

REA PROPOSED SPECIFICATION

for

THERMOPLASTIC INSULATED THERMOPLASTIC
SHEATHED TELEPHONE CABLE

1. SCOPE

1.1 This specification covers the requirements for telephone cable having solid copper conductors, with thermoplastic insulation. The insulated conductors are twisted into pairs, the required number of pairs stranded into a cable, and enclosed in a thermoplastic sheath or jacket.

1.2 Conductors of only one gauge shall be used in any given length of cable.

1.3 Insulation on conductors shall be polyethylene.

1.4 The number of pairs shall be in accordance with the following table:

Actual Number of Pairs

6
11
16
26
51
76
101

1.5 Alternative materials for sheath are (a) polyethylene and (b) plasticized polyvinyl chloride.

2. CONDUCTORS

- 2.1 Each conductor shall be a solid round wire of commercially pure annealed copper. Conductors shall meet the requirements of ASTM Designation B-3, latest issue.
- 2.2 The sizes of wire used and their nominal diameters are shown in the following table.

<u>American Wire Gauge</u>	<u>Nominal Diameter-Inch</u>
No. 19	0.0359
No. 22	0.0253
No. 24	0.0201
No. 26	0.0159

These four wire sizes will be required for all numbers of pairs listed in Par. 1.4, except No. 19 gauge wire which will be required in the 6-pair cable.

- 2.3 Joints made in conductors during the manufacturing process may be brazed, using a silver alloy solder and a nonacid flux, or they may be welded. In joints, the two ends of conductor shall be butted. Joints shall be free from lumps and sharp projections.
- 2.31 The tensile strength of any section of a conductor, including a factory joint, shall be not less than 85 percent of the tensile strength of an adjacent section of the solid conductor of equal length without a joint.

3. INSULATION

- 3.1 Each conductor shall be insulated with polyethylene. The polyethylene shall meet the requirements for Dielectric Material, Type II, Grade 5, ASTM Designation D-1248, latest issue.
- 3.2 Specimens of insulation, removed from conductors, shall meet the tensile and elongation requirements for Dielectric Material, Type II, Grade 5, ASTM Designation D-1248, latest issue.
- 3.3 The wall thickness and the concentricity of the insulation shall be such that the insulated conductors will satisfy the requirements for Capacitance (Par. 10) and Dielectric Strength (Par. 12.)
- 3.4 When necessary for conductor identification, the polyethylene shall be colored.

4. TWISTING OF PAIRS

- 4.1 The insulated conductors shall be twisted into pairs. The colors of insulation on the wire and mate and the number of like-colored pairs in a color group shall be as given in the following table:

Pairs in Cable	Colors of Insulation			
	Wire	Red	Blue	Red
	Mate	Natural or White	Natural or White	Orange or Blue
Number of Pairs				
6		5		1
11		10		1
16		15		1
26		25		1
51		50		1
76		75		1
101		49	50	2

4.2 The lengths of twist of pairs shall be such that, when stranded into cable, adjacent pairs in a layer, and pairs in adjacent layers shall have different lengths of twist. Suggested maximum lengths of pair twist are given in the following table.

<u>Gauge</u>	<u>Suggested Maximum Length of Pair Twist - Inches</u>
19	6
22	5
24	4
26	4

NOTE: In order that crosstalk may be minimized, the pair twists are to be designed to enable the cable to meet the capacitance unbalance limits stated in Par. 11.

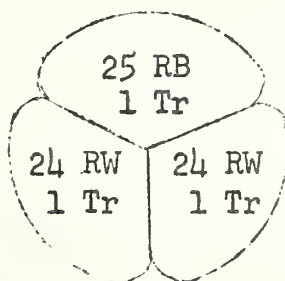
5. FORMING OF CABLE

5.1 The twisted pairs shall be arranged in layers to form a cylindrical core. Adjacent layers may be stranded in the same direction or in opposite directions. No fillers shall be used.

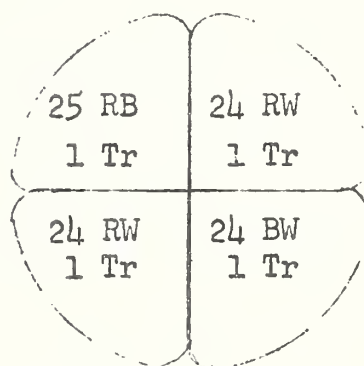
5.2 When more than one color group is used, the Red-Natural group shall be in the center position with the Blue-Natural group in the outer position.

5.3 The tracer pair (Red-Orange or Red-Blue) shall be located in the outside layer. In the 101-pair cable, a second tracer pair shall be located in the outside layer of the Red-Natural group.

5.4 For 76 and 101-pair cables, an alternative method of cabling may be used. In this method, the cable is formed of units, each unit containing 25 or 26 pairs. The arrangement of units in the core, and the make-up of the units are shown in the following diagram.



76-pair cable



101-pair cable

RB - One wire of pair Red, other wire Blue
RW - One wire of pair Red, other wire White (or Natural)
BW - One wire of pair Blue, other wire White (or Natural)
Tr - Tracer, Red paired with Orange

5.5 The core (or each unit) shall be bound with an open helix of colored thread or tape (preferably of a non-hygroscopic material). This binder shall be colored to indicate the gauge of conductors, in accordance with the following table:

19 gauge - blue binders on units
22 gauge - white binders on units
24 gauge - red binders on units
26 gauge - orange binders on units

6. CORE COVERING

6.1 The stranded core shall be covered with a layer of non-hygroscopic dielectric material (polyethylene suggested) of thickness necessary to assure the dielectric strength between the core and shield specified in Par. 12. All parts of the core shall be completely covered.

(If desired by the manufacturer, an additional covering may be applied over the non-hygroscopic covering. This is to be considered primarily as heat insulation to prevent damage to the polyethylene or other thermoplastic during subsequent sheathing or jacketing operations.)

7. SHIELD

7.1 An electrostatic shield of copper or aluminum shall be applied over the core. The shield shall completely cover the core and shall be so constructed that it will not cause difficulty in bending the cable.

Cable Size Pairs	Resistance of Shield - Ohms per 1000 feet			
	19 Ga.	22 Ga.	24 Ga.	26 Ga.
6		-	-	-
11				
16				
26				
51				
76				
101				

NOTE: A low shield resistance is desirable, but at this time it seems impracticable to specify values. It is expected that the manufacturer will furnish to REA the shield resistance applicable to his product.

The shield resistance should approximate that of lead alloy sheath used on lead covered telephone cables. This is of the order of 0.6 ohm per 1000 feet, for a cable having a diameter of one inch under the sheath.

8. IDENTIFICATION MARKER

8.1 Each length of cable shall be permanently identified as to manufacturer and time of manufacture. The marker may be a tape on which the manufacturer's name and the year of manufacture are stamped or printed at intervals of approximately one foot applied either over or under the shield. An approved equivalent may be used.

9. SHEATH

9.1 An outer sheath or jacket shall be applied over the shielding tape. This jacket may be either polyethylene or plasticized polyvinyl chloride.

The jacket shall provide the cable with a tough, flexible, long-lived protective covering, able to withstand sunlight and the atmospheric temperatures, and stresses reasonably expected in

normal installation. Air temperatures that may be encountered during installation may be as low as -20F (-30C) or as high as 120F (50C).

The jacket shall be free from holes, splits, blisters, or other imperfections. It shall be smooth, and of uniform composition throughout.

- 9.2 POLYETHYLENE for cable sheath shall have incorporated in it carbon black and anti-oxidant in proper quantities to result in satisfactory aging characteristics. It shall meet the requirements for Type II - Dielectric Material - Grade 6 - ASTM Designation D-1248, latest issue, except that the melt index shall be 0.31 to 0.53.

In addition, the following requirements shall be met.

Light Absorption - The coefficient of light absorption shall be not less than 3500, when measured with incandescent illumination.

Heat Shock - The cable sheath shall show no cracks when tested as described in ASTM Designation D-1047, latest issue, except that the temperature shall be 99 to 101C.

Cold Bend Test - The cable sheath shall show no cracks when tested as described in ASTM Designation D-1047, latest issue, except that the temperature shall be -60C.

Heat Distortion - Specimens of the cable sheath shall not decrease in thickness more than 50 percent when tested in accordance with ASTM Designation D-1047, latest issue, except that the temperature shall be 99 to 101 C.

9.3 PLASTICIZED POLYVINYL CHLORIDE compound for sheath or jacket shall meet the requirements of ASTM Designation D-1047, latest issue, with the following exceptions:

The compound shall contain sufficient carbon black to insure a long life when exposed to sunlight.

The physical properties shall be as follows:

Tensile strength - minimum - psi -	1800
Elongation at rupture - minimum - percent	150
Tensile strength after 7 days in air oven at 99 to 101C - minimum percent of original value	85
Elongation at rupture after 7 days in air oven at 99 to 101C - minimum percent of original value	60

Cold bend test - In accordance with ASTM Designation, latest issue, D-1047, except that temperature shall be -40C.

9.4 The thickness of sheath shall be as shown in the following table:

<u>Diameter under sheath</u>	<u>Average thickness of sheath</u>
0.5 inch and under	0.05 inch
0.51 inch to 0.75 inch	0.06 inch
0.76 inch to 1.00 inch	0.07 inch
1.01 inch to 1.25 inch	0.08 inch
1.26 inch to 1.50 inch	0.09 inch

The average thickness of sheath shall be maintained to a tolerance of +.015 inch and -.010 inch. Maximum and minimum spot thickness shall not exceed ± 25 percent of the sheath thickness specified.

10. CAPACITANCE

10.1 The average mutual capacitance of the pairs in a cable measured at 1000 cps ($\pm 10\%$) shall be not greater than given in the following table.

<u>Gauge of Conductors</u>	<u>Maximum Average Mutual Capacitance</u>
	Microfarads per mile
19	.09
22	.09
24	.09
26	.09

Mutual capacitance is the capacitance between the two wires of a pair with all the other wires in the cable connected to the shield, and grounded.

11. CAPACITANCE UNBALANCE

11.1 The pair-to-pair capacitance unbalance between pairs adjacent in a layer, and between pairs in the center and pairs in the immediately adjacent layer shall not exceed the following limits:

Average for any reel. 70 mmf

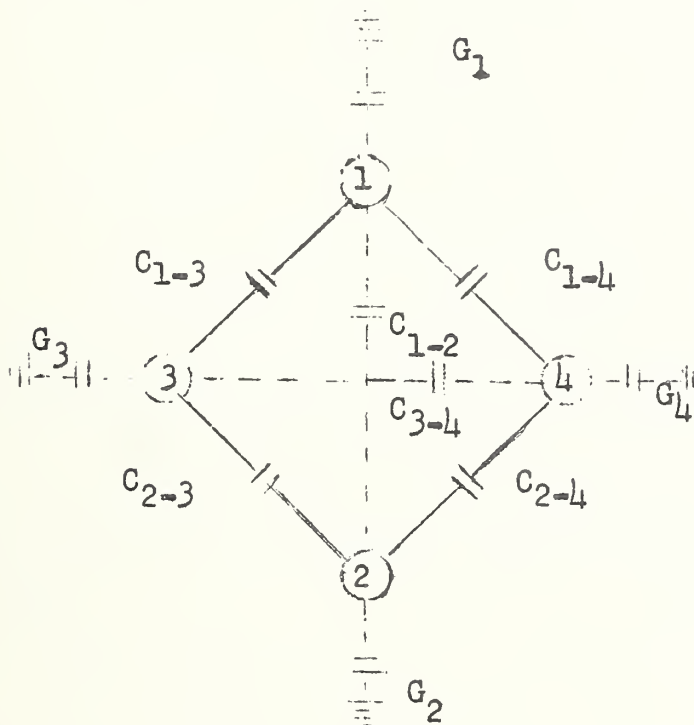
Highest value in any reel. 280 mmf

The values given apply to 1,000 foot lengths of cable. For other lengths of cable, the values shall be converted to 1,000 foot values by dividing the unbalance of the length measured

by the square root of the ratio of the length measured to 1,000.

Average unbalance is the numerical average of the unbalance readings without regard to signs.

The capacitances involved in and the definition of pair to pair unbalances are shown in the diagram below:



1 and 2 represent the two wires of a pair, 3 and 4 represent the two wires of a second pair.

The capacitances are the direct capacitances between conductors.

Direct capacitance is defined in American Standard Definitions of Electrical Terms. (1941 Definition 05.15.080.)

The pair-to-pair capacitance unbalance is $(C_{1-4} + C_{2-3}) - (C_{1-3} + C_{2-4})$.

12. DIELECTRIC STRENGTH

12.1 In each length of cable, the insulation between conductors shall be capable of withstanding for two seconds a 60-cycle potential of approximately sine wave form whose value is not less than 1000 volts, rms.

12.2 In each length of cable, the insulation between the shield and conductors in the core shall withstand for two seconds a 60-cycle potential of approximately sine wave form whose value is not less than 3500 volts, rms.

13. INSULATION RESISTANCE

13.1 Each conductor in each length of cable, when measured against all the other conductors and the shield, grounded, shall have an insulation resistance of not less than 1000 megohm-miles. The measurement shall be made with a dc potential of not less than 100 nor more than 550 volts, applied for not more than one minute.

14. DEFECTIVE PAIRS

14.1 Each length of cable shall be free from grounds (contacts between a conductor and the shield).

14.2 Conductor faults (opens and short circuits) shall not involve more than one pair in any length of cable.

NOTE: Conductor faults in cables having only a small number of pairs impose a relatively severe impairment to the use of

the cable. It is expected therefore that the manufacturer will take care to limit, as far as practicable, the supply of cable having defective pairs.

14.3 Defective pairs shall be suitably marked at both ends of the cable with the nature of the defect indicated.

15. CONDUCTOR RESISTANCE

15.1 The resistance of any conductor in a length of cable shall not exceed the value given in the following table.

<u>Gauge</u>	<u>Equivalent Resistance at 68°F</u>
AWG	Ohms per mile
19	46
22	92
24	145
26	230

16. MANUFACTURING IRREGULARITIES

16.1 Conductor joints - See Par. 2.3

Where conductor joints in insulated conductors are required, the insulation shall be restored on the joint. The diameter over the repaired part shall be held as nearly as practicable to the diameter over the insulation on the unrepaired section.

16.2 Repairs to the sheath or jacket, when required, shall be made in such a manner that there shall be no loss in electrical or physical properties. Any repaired part shall be capable of meeting the requirements applying to the sheath. (Par. 9)



17. GUARANTEE

17.1 The supplier of cable under this specification shall agree to replace any length of cable found to be defective in workmanship or material within one year from the date of installation (not more than two years from the date of manufacture).

18. PREPARATION FOR SHIPMENT

18.1 Each length of cable shall be wound on a separate reel, unless otherwise specified by the purchaser. The reels shall be substantial and so constructed as to prevent damage to the cable during transit. The diameter of the drum shall be large enough to prevent damage to the cable from reeling. Lags or other means of protection shall be applied to the reel and suitably secured in place to prevent damage to the cable during storage or shipment.

The arbor hole shall admit a spindle 2 1/2 inches in diameter without binding.

18.2 Each end of every length of cable shall be effectively sealed to prevent the entrance of moisture. The seal shall be applied in such a way as to prevent damage to the conductors or defective pair tags, if any.

18.3 The outer end of the cable shall be securely fastened to the reel head, so as to prevent the cable becoming loose in transit. The inner end of the cable shall project into a slot in the

side of reel, or into a housing on the inner side of the drum in such a way as to make it available if required for test. The inner end shall be fastened to prevent it from becoming loose during installation.

18.4 Each reel shall be plainly marked to indicate the direction in which it should be rolled to prevent loosening of the cable on the reel.

18.5 Each reel shall be stenciled or lettered with the name of the supplier and the length and description of the cable.

